MULTIPLE-CHOICE QUESTIONS

1. The majority of the rocks in the Earth's crust are:

   (A) igneous
   (B) metamorphic
   (C) sedimentary
   (D) basalt
   (E) volcanic

2. Which of the following is an example of an igneous rock?

   (A) Marble
   (B) Slate
   (C) Limestone
   (D) Granite
   (E) Sandstone

3. The smallest particle of soil is known as

   (A) clay
   (B) sand
   (C) silt
   (D) gravel
   (E) humus

4. Acid rain affects soil by

   (A) decreasing soil porosity
   (B) decreasing the pH
   (C) decreasing soil aeration
   (D) lowering nutrient capacity
   (E) all of the above

5. Which of the types of soil listed below contains the highest amount of nutrients?

   (A) clay
   (B) silt
   (C) sand
   (D) gravel
   (E) loam

6. An example of a volcano with broad, gentle slopes and built by the eruption of runny, fluid-type basalt lava would be

   (A) Mount Saint Helens
   (B) Krakatau
   (C) Kilauea
   (D) Vesuvius
   (E) Mount Rainier

7. Which of the following is at a convergent boundary where two continental plates are presently colliding?

   (A) The Appalachian Mountains
   (B) The Himalayas
   (C) The Andes Mountains
   (D) The Rocky Mountains
   (E) None of the above

8. The Dust Bowl of the 1930s resulted in the passage of what legislation?

   (A) Endangered American Wilderness Act
   (B) Soil and Water Conservation Act
   (C) Federal Land Management Act
   (D) Public Rangelands and Improvement Act
   (E) Soil Erosion and Conservation Act

9. Poor nutrient-holding capacity, good water infiltration capacity, and good aeration properties are examples of what type of particle found in soil?

   (A) Clay
   (B) Silt
   (C) Sand
   (D) Loam
   (E) Humus

10. An alkaline, dark soil, rich in humus, found in a semiarid climate would be most characteristic of

    (A) deserts
    (B) grasslands
    (C) tropical rain forests
    (D) deciduous forests
    (E) coniferous forests

11. Which period in geological time describes the following: "Development of flowering plants. Large diversity in dinosaurs but ending with their sudden extinction approximately 65 million years ago. Formation of the Andes Mountains. African and South American plates begin to separate. Climate is cooling. Shallow seas are prominent."?

    (A) Paleogene
    (B) Neogene
    (C) Jurassic
    (D) Cretaceous
    (E) Permian

12. The process of weathering produces what type of rock?

    (A) Igneous
    (B) Metamorphic
    (C) Sedimentary
    (D) Volcanic
    (E) None of the above

13. A rock that would most likely contain a fossil would be

    (A) igneous
    (B) metamorphic
    (C) sedimentary
    (D) volcanic
    (E) all of the above

14. The most common element found in Earth's crust is

    (A) oxygen
    (B) hydrogen
    (C) iron
    (D) silicon
    (E) aluminum

15. The horizon of soil also known as the topsoil layer, that contains humus, minerals, and roots, and that is rich in living organisms is known as the

    (A) A layer
    (B) B layer
    (C) C layer
    (D) D layer
    (E) O layer

16. Earth is closest to the sun in the Northern Hemisphere during

    (A) winter
    (B) summer
    (C) spring
    (D) fall
    (E) all seasons

17. An earthquake of Richter magnitude 5 is how many times larger on the Richter scale than an earthquake of Richter magnitude 3?

    (A) One-fourth
    (B) One-half
    (C) Twice
    (D) Four times
    (E) One hundred times

Refer to the following table to answer Question 18.

	Most Stable	Least Stable
A	Bedrock	Sand
B	Unconsolidated sand	Bedrock
C	Clay	Bedrock
D	Sand and mud	Clay
E	Water-saturated sand	Sand

18. Which of the choices above represents the most stable and the least stable foundation material to build upon in areas that are frequented by earthquakes?

(A) A
(B) B
(C) C
(D) D
(E) E

19. The San Andreas Fault in California occurs at

(A) a convergent boundary
(B) a divergent boundary
(C) a transform boundary
(D) a subduction zone
(E) an oceanic ridge

20. Earth's surface is part of the

(A) asthenosphere
(B) lithosphere
(C) benthosphere
(D) troposphere
(E) stratosphere

FREE-RESPONSE QUESTION

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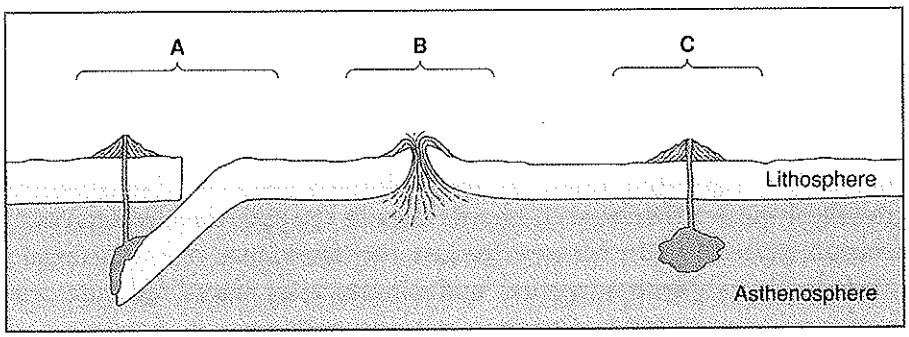
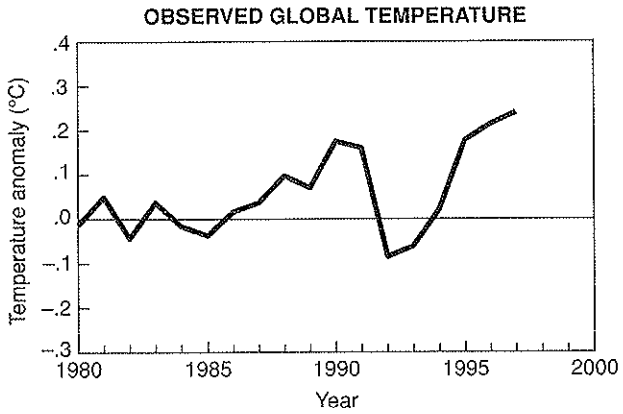


(a) Geological features A–C above are formed as a consequence of plate tectonics. Chose two of these features and

(i) describe what is occurring there
(ii) give an actual geographic example

(b) Charles Darwin was the geologist, botanist, and zoologist on the research vessel *Beagle* when he made observations that lead to his book, *The Origin of Species*, in which the theory of evolution and natural selection was first introduced. A century later, scientists developed the theory of plate tectonics, describing how the solid Earth formed. Describe two ways in which evolution may occur as a consequence of plate tectonics.

(c) Mount Pinatubo in the Philippines erupted in 1991. Examine the temperature graph below and answer the following questions.



(i) Compare Earth's climate before after the eruption of Mount Pinatubo.
(ii) Explain how the eruption of Mount Pinatubo might affect short-term and long-term climate change.

MULTIPLE-CHOICE ANSWERS AND EXPLANATIONS

1. **(A)** Igneous rocks are solidified from magma. If the magma cools slowly, the rocks are coarser in nature. Had the question been worded "the majority of the rocks on the surface of Earth," the answer would have been sedimentary.
2. **(D)** Other examples of igneous rocks include basalt and quartz.
3. **(A)** Clay is the smallest-sized particle found in soil.
4. **(E)** Acid rain causes calcium and magnesium compounds to be leached from the soil, which decreases the natural buffering effect and reduces the soil pH (makes it more acidic). Acids release toxic materials from compounds and are absorbed by vegetation (mercury, lead, cadmium, etc.). Acid rain promotes the growth of mosses that tend to retain water in the soil, thereby decreasing soil aeration (waterlogged). Mosses decrease the abundance of mycorrhizal fungi that help plants absorb nutrients. Acid rain decreases plants' resistance, making them more susceptible to disease, insects, drought, etc.
5. **(E)** Loam is soil composed of sand, silt, and clay in relatively even concentrations. Loam soils generally contain more nutrients and humus than sandy soils, have better infiltration and drainage than silty soils, and are easier to till than clay soils.
6. **(C)** Kilauea is a shield volcano that is characterized by basalt lava building enormous, low-angle, gently sloping cones. The fluid nature of the lava prevents it from piling in steep mounds. Shield volcanoes occur along the mid-oceanic ridge, where seafloor spreading is in progress and along subduction zones related to volcanic arcs. The largest volcanoes on Earth are shield volcanoes.
7. **(B)** Notice the word "presently." The Appalachian and Rocky mountains were formed at *ancient* convergent plate boundaries. The Andes lie at a convergent boundary where oceanic lithosphere is being subducted under the South American continent.
8. **(B)** Refer to the case study presented in this chapter.
9. **(C)** Water flows through sandy soils too fast for many crops and requires frequent irrigation.
10. **(B)** Soils found in grasslands are rich in organic nutrients.
11. **(D)** Refer to the section "Geologic Time Scale" in this chapter.
12. **(E)** This is another trick question. Weathering does not produce rock.
13. **(C)** Sedimentary rock is formed by the piling of material over time. If conditions are right, organisms that die may be covered by this material and become fossilized. Fossils are impressions made up of minerals.
14. **(A)** Eight elements make up 99% of Earth's crust. In order of decreasing abundance, they are oxygen, silicon, aluminum, iron, calcium, sodium, potassium, and magnesium.
15. **(A)** If the topsoil is brown or black, it is rich in nitrogen and is good for crops. If the topsoil is gray, yellow, or red, it is low in organic matter and poor for crops.
16. **(A)** The angle of sunlight determines the season, not how close Earth is to the sun.

17. **(E)** The Richter scale is a log-based scale. $5 - 3 = \underline{2}$ and $10^{\underline{2}} = 100$. However, the Richter scale does NOT measure the energy of an earthquake. The energy of a Richter magnitude 5 has 32 times more energy than a Richter magnitude of 4.
18. **(A)** Soil type can substantially increase earthquake risk. The worst soils to build upon include deep, loose sand; silty clays; sand and gravel; and soft, saturated granular soils. Earthquake forces are amplified on water-saturated soils, changing the soil from a solid to a liquid, a process known as liquefaction. Liquefaction makes the ground incapable of supporting a foundation. During liquefaction, the ground can crack or heave, causing uneven settling or building collapse. The best soils to build upon to reduce damage from earthquakes are bedrock (deep and unbroken rock formations) and stiff soils. These soil types are best, since much less vibration is transferred through the foundation to the structure above.
19. **(C)** Places where plates slide past each other are called transform boundaries. The most famous transform boundary in the world is the San Andreas fault.
20. **(B)** The asthenosphere is below the lithosphere.

FREE-RESPONSE ANSWER

(a) Feature *A* is a subduction zone. One lithospheric plate is subducting (sinking) below another, largely due to differences in density (the denser plate sinks). This is an example of a convergent plate boundary. As the subducted plate sinks to greater depths, the temperature increases to the point where it begins to melt. This molten magma is less dense than the solid rock around it, so it rises up and forms a chain of volcanic mountains parallel to the plate boundary. The Cascade Mountains in Washington State are examples of a volcanic arc. When two oceanic plates converge, they create an island arc—a curved chain of volcanic islands rising from the deep seafloor and near a continent. They are created by subduction processes and occur on the continent side of the subduction zone. Japan is an example of an island arc.

Feature *B* is a divergent plate boundary. Lithospheric plates are moving apart. The space created between them is filled by hot molten magma coming up from the asthenosphere that then cools and adds to the crust. In oceanic crust, they are known as a mid-oceanic ridge. The Mid-Atlantic Ridge is an example. When they form on continental crust, they are known as rift valleys, such as the African Rift Valley.

Feature *C* is a hot spot. This is a place in the asthenosphere where the temperature is higher than average such that localized melting occurs. This molten rock, being less dense due to its temperature and state of matter, rises up. It forms a volcano on Earth's surface. Over geologic time, the location of the hot spot remains constant, whereas the lithospheric plate moves over it. This causes a chain of volcanoes to form over time from a single hot spot. The Hawaiian Islands are an example of the consequences of hot spots.

(b) Evolution may occur as a consequence of geographic separation of one population of a species into two or more populations. Plate tectonics may cause this separation by either of two methods.

First, a divergent (constructive) plate boundary could cause one landmass to be divided into two or more distinct parts, perhaps even separated by an ocean. For example, identical fossils can be found on the east cost of South America and the west coast of Africa, indicating that these were once the same connected landmass. After these two continents diverged, different species would evolve from this common ancestor as a reaction to the different environments and consequent environmental pressures on the different landmasses.

Second, faulting occurring as a consequence of plate tectonics may cause a river to be diverted. The new path of the river could divide a population into two and serve as a geographic barrier preventing gene flow. Different conditions in geographically separated regions would eventually lead to the evolution of different species as each population adapted to its environment in different ways.

Plate tectonics may result in climatic change in one of the following ways: First, Earth's atmosphere has changed considerably throughout geological history, largely as a consequence of gases emitted through volcanic activity caused by plate tectonics. These changes in the atmosphere have caused climate change. For example, there is evidence that the Earth was much warmer hundreds of millions of years ago.

Second, lithospheric plates move over the surface of Earth at speeds of a few centimeters a year. Individual plates have moved thousands of miles over geologic history. As the latitude of the plate changes, so will its climate. For example, some rocks in Alaska indicate that they were originally deposited at a time when the plate had a tropical climate and so must have been closer to the equator.

Species evolve in reaction to these climate changes. For example, animals will adapt to shifting food sources as different plants grow in different climates. A species of animal may develop fur over time (through natural selection) as temperatures decrease over time.

As lithospheric plates move to latitudes farther from the equator, climates will have greater seasonal variations. This could lead to evolutionary adaptations such as plants shedding their leaves to conserve resources or animals hibernating during winter months to conserve energy.

Evidence suggests that some mass extinctions in Earth's history may have been caused by large-scale volcanic activity, such as flood basalts, which occur as a consequence of plate tectonics. These mass extinctions tend to be followed by periods with high rates of evolution (punctuated) and increase in species diversity (adaptive radiation) as ecological niches are filled.

(c)

(i) After the eruption of Mount Pinatubo, Earth's temperature was approximately 0.3°C lower for the next two years. Earth's temperature rose by approximately 0.1°C during the third year. By the fourth year after the eruption, Earth's temperature had returned to the pre-eruption level.

(ii) In the short term, dust and other particulates released into the atmosphere from the eruption would block the Sun's rays and tend to decrease temperatures. For example, sulfur dioxide gas that is injected into the stratosphere from volcanic activity chemically reacts with oxygen to form sulfate aerosols (solid particles), which tend to reflect solar radiation back into space.

The aerosol remains in suspension long after solid ash particles have fallen to Earth. Without replenishment, the sulfuric acid aerosol layer is gradually depleted. This decrease in energy reaching the Earth would result in lower global temperatures. Fine ash particles from an eruption column fall out too quickly to significantly cool the atmosphere over an extended period of time.

In the long term, gases such as carbon dioxide released during the eruption would accumulate in the stratosphere. There they would contribute to the greenhouse effect. They would absorb energy radiated back from the Earth, leading to an increase in global temperature. The degree of temperature change from the Mount Pinatubo eruption via this mechanism would be much less than that by dust blocking the sun, but the effect would last much longer.